IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte Furukawa

Appeal No. _____

Appellants:	Furukawa et al.
Serial No.:	10/814,482
Filed:	March 31, 2004
Art Unit:	2818
Examiner:	David J. Goodwin
Title:	METHOD FOR FABRICATING STRAINED SILICON-ON-INSULATOR STRUCTURES AND STRAINED SILICON-ON-INSULATOR STRUCTURES FORMED THEREBY
Confirmation No.:	6082
Attorney Docket:	ROC920030399US1

Cincinnati, OH 45202 December 14, 2007

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REPLY BRIEF

I hereby certify that this correspondence for Application No. 10/814,482 is being electronically transmitted to Technology Center 2818, via EFS-WEB, on December 14, 2007.

/William R. Allen/
William R. Allen, Reg. No. 48,389

December 14, 2007
Date

I. Status of the Claims

Claims 1-15 are rejected and claims 16-34 are cancelled. Claims 1-15 are now on appeal.

II. Grounds of Rejection to be Reviewed on Appeal

1. Claims 1-11 and 13-15 stand rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Pub. No. 2003/0111699 to Wasshuber et al.

2. Claims 1-4, 6-12, 14, and 15 stand rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Pub. No. 2004/0150042 to Yeo et al.

III. Argument

Appellants respectfully submit that the Examiner's responses in the November 1, 2007 Answer to the arguments submitted in Appellants' September 24, 2007 Appeal Brief are not supported on the record, and that the rejections of claims 1-15 should be reversed for at least the reasons originally set forth in Appellants' September 24, 2007 Appeal Brief and for the additional reasons set forth herein that rebut the statements in the November 1, 2007 Answer.

A. *Claims 1-11 and 13-15 were improperly rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Pub. No. 2003/0111699 to Wasshuber.*

In paragraphs 61, 69, and 70 of the November 1, 2007 Answer, the Examiner states that "[t]he impact of the implanted oxygen on the lattice structure is the result of said species modifying and incorporating into the lattice. When oxygen incorporates and bonds with silicon atoms the result is silicon oxide, silicon oxide is an insulator." (quoting from paragraph 61).

In making this statement, the Examiner has failed to comprehend that merely implanting oxygen ions into crystalline silicon does not in and of itself form oxide by a "chemical reaction." *Wasshuber* fails to explicitly disclose that the implanted oxygen forms an oxide layer or any other type of compound with electrically insulating properties, and fails to explicitly disclose that first region (512) is an insulator. However, paragraph [0021] of *Wasshuber* discloses "[d]ue to the impact of such implantation on the lattice structure of the silicon in the first regions 12, volumetric expansion or contraction can be achieved by controlling the dosage of the implantation to achieve any desired concentration of implanted species within the silicon." Note that *Wasshuber* refers to volumetric expansion or contraction in the lattice structure of the silicon in the first region (12), which is formed in the same manner as the first region (512). Therefore, the ion implanted silicon in the first regions (12) retains a lattice structure characteristic of silicon and is not an insulator

Silicon substrates, such as the substrate used to form the device (10) in *Wasshuber*, have a crystalline lattice structure. The introduction of a low concentration of oxygen by ion implantation into crystalline silicon, as disclosed in *Wasshuber*, forms a solid solution, which would have been understood by a person having ordinary skill in the art to be a solid-state

solution of one or more solutes in a solvent. The solid solubility limit of oxygen in silicon is on the order of one oxygen atom per 5000 silicon atoms. Such a mixture is considered a solution, rather than a compound, when the crystal structure of the solvent remains unchanged by addition of the solutes, and when the mixture remains in a single homogeneous phase. The solute may incorporate substitutionally into the solvent crystal lattice by replacing a solvent atom in the crystal lattice, or solute may incorporate interstitially by fitting into a space between solvent atoms in the crystal lattice. Both of types of solid solution affect the properties of the material by distorting the crystal lattice and disrupting the physical and electrical homogeneity of the solvent material. It is precisely this distortion that causes the expansion of the silicon lattice in *Wasshuber*.

However, a solid solution is not a compound produced by some sort of a chemical reaction between oxygen and silicon. This is a fundamental misunderstanding of the disclosure in *Wasshuber* by the Examiner.

As would have been appreciated by a person having ordinary skill in the art, the solid solubility limit of oxygen in silicon can be exceeded. However, this results in the formation of precipitates containing oxygen and silicon. These precipitates, which are dispersed in the silicon, are isolated clusters that are randomly distributed and are not organized to in any way define a continuous layer. A dose of ion implanted oxygen sufficient to form such precipitates will destroy the original lattice structure of the silicon so that the silicon in the region containing the oxygen will be highly damaged and likely amorphous (i.e., a material lacking long-range order that is characteristic of a crystalline material like silicon in substrates used to build integrated circuit devices).

As would have been appreciated by a person having ordinary skill in the art, a layer of silicon dioxide can be intentionally formed on a crystalline silicon substrate by a high-temperature thermal oxidation process. The oxide layer that forms is a compound produced by a chemical reaction between oxygen and silicon. The stochiometric compound in the oxide layer contains two oxygen atoms for every silicon atom. However, silicon dioxide formed by oxidation is amorphous. The silicon dioxide layer does not retain the silicon lattice structure, the

silicon dioxide layer does not have a "silicon oxide lattice"[1], and the oxygen is not in a solid solution with the lattice structure of silicon. *Wasshuber* does not disclose the use of a thermal oxidation process to form first region (512), but instead discloses the use of ion implantation.

As also would have been appreciated by a person having ordinary skill in the art, a thin layer of native oxide forms on a silicon substrate exposed to the ambient atmosphere. The native oxide layer that forms is a compound produced by a chemical reaction between oxygen and silicon. The stochiometric compound in the native oxide layer contains two oxygen atoms for every silicon atom. However, native oxide is amorphous. The native oxide layer does not retain the silicon lattice structure, the silicon dioxide layer does not have a "silicon oxide lattice" as insisted by the Examiner, and the oxygen is not in a solid solution with the silicon. *Wasshuber* fails to disclose that first region (512) is composed of native oxide, but instead discloses that the first region (512) is formed by ion implantation.

As would have been appreciated by a person having ordinary skill in the art, a buried layer of silicon oxide can be formed as an insulator in a silicon substrate by ion implantation. However, this requires a highly specialized separation by a separation by implantation of oxygen (SIMOX) process to form a stochiometric compound containing two oxygen atoms for every silicon atom. However, the SIMOX oxide is amorphous. The SIMOX oxide layer does not retain the silicon lattice structure, the silicon dioxide layer does not have a "silicon oxide lattice" as insisted by the Examiner, and the oxygen is not in a solid solution with the silicon. A SIMOX process requires an extremely high implanted dose of oxygen that exceeds the solid solubility limit of oxygen in silicon, followed by a thermal anneal to transform the implanted zone into an oxide layer. *Wasshuber* fails to disclose that first region (512) is formed by a SIMOX process.[2] A person having ordinary skill in the art would understand that a SIMOX process could not be used to form the first region (512). Instead, *Wasshuber* discloses the use of ion implantation to form the first region (512).

Hence, the Examiner's rebuttal argument presented in the November 1, 2007 Answer is not technically sound. First region (512) in *Wasshuber* includes ion implanted oxygen that is in

[1] See paragraph 73 of the Examiner's Answer.

[2] On page 4 of Appellants' specification, Appellants describe that a SOI substrate (10), which is used as a starting structure that is modified by the process forming the semiconductor structure set forth in Appellants' claim 1, can be formed using a SIMOX process.

solid solution within the lattice structure of the crystalline silicon. The ion implanted oxygen does not react chemically with the silicon to form oxide. Hence, first region (512) is not composed of silicon oxide and first region (512) is not an insulator that could be reasonably considered to be an insulating layer.

In paragraph 72, the Examiner contends that "[t]o undergo expansion the lattice structure must be changed, when this structural change is caused by oxygen the change is the transformation of silicon lattice to a silicon oxide lattice." This, of course, is incorrect. If the silicon and oxygen are organized into a "silicon oxide lattice", the material must be crystalline silicon dioxide and take a solid form such as quartz. To Appellants' knowledge, it is not possible to implant oxygen into crystalline silicon and somehow form a crystalline material having "a silicon oxide lattice." To reiterate, the oxygen forms a solid solution with the silicon lattice structure. The silicon lattice structure is retained after the oxygen is implanted into it and after the device (520) is formed.

In order for a reference to anticipate the invention in a claim, the reference must teach each and every element in the precise arrangement set forth in the claim. *See* MPEP § 2131. *Wasshuber* fails to disclose "an insulating layer disposed between said island and said handle wafer." For this reason alone, Appellants respectfully request that the Board reverse the Examiner's rejection of claim 1 under 35 U.S.C. § 102(e).

In paragraphs 62, 63, and 73-79 of the November 1, 2007 Answer, the Examiner characterizes Appellants' argument that "Wasshuber fails to disclose that any portion of the implanted region is thicker than any other portion of the implanted region" as "frivolous" because claim 1 does not claim that any portion is thicker than any other portion. (quoting from paragraphs 62 and 63).

Appellants' claim 1 unambiguously recites "an insulating layer" and that the insulating layer contains "a thickened region underlying said strained region" of the semiconductor island. Appellants fail to appreciate a person having ordinary skill in the art could construe the language "a thickened region" to mean anything other than a portion of the insulating layer in the thickened region is thicker than another portion of the insulating layer outside of the thickened region of the insulating layer. Appellants believe that the Board will recognize that the thickened region is a structural component of the insulating layer and that the Board will further recognize

that this is clearly not a "frivolous argument" as contentiously stated by the Examiner in the November 1, 2007 Answer.

On page 9 of the November 1, 2007 Answer, the Examiner contends in paragraph 64 that "Wasshuber clearly states that the implanted region has undergone a volumetric expansion (paragraph 0021) which necessarily requires an increase in the thickness." Appellants agree that the implanted first region (512) will experience a thickening relative to the surrounding crystalline silicon of substrate (14) because of the volumetric expansion. However, the Examiner continues in paragraph 64 that "as the appellant claims the structure rather than the method of making a device, no patentable weight is accorded to a process limitation such as thickening." Appellants fail to comprehend how this statement by the Examiner follows logically from the preceding sentence in paragraph 64. As best understood by the Appellants, this statement by the Examiner ignores that claim 1 does not use the term "thickening." Claim 1 does not set forth a process (i.e., oxidation) for thickening a region of the insulating layer to produce the claimed thickened region. Instead, claim 1 recites a "thickened region" in the insulating layer, which is a structural limitation and not a process limitation.

On page 9 in paragraphs 65 and 66 of the November 1, 2007 Answer, the Examiner states "[t]he appellant *(sic)* that Wasshuber discloses that the insulating layer (512) has the a *(sic)* uniform thickness across the entire width." The Examiner further characterizes this argument as "clearly a false statement" and refers to disclosure in Figure 22 of *Wasshuber* allegedly teaching "that the insulating layer (512) comprises a central portion that is thicker than the end portions." Assuming for purposes of argument that first region (512) in *Wasshuber* is an insulating layer, which Appellants dispute for reasons explained above, *Wasshuber* fails to explicitly disclose that any sub-region of the first region (512) is thickened. Instead, *Wasshuber* discloses that "an implantation process 517 is performed to implant a desired species (e.g., such as carbon, germanium, oxygen, or the like) in a first region 512 underlying the prospective transistor device area **between first and second depths 516a and 516b**." (Emphasis added in bold by Appellants). A person having ordinary skill in the art would have understood from this disclosure in *Wasshuber* that the first region (512) has a uniform thickness extending between a first depth (516a) and a second depth (516b). Stated differently, the numerical difference

between the first and second depths (516a, 516b) is a single numerical value representing a uniform thickness.

As explained above, any expansion of the first region (512) produced by the implanted oxygen is relative to the surrounding crystalline silicon of which substrate (14) is composed.

As paragraphs 65 and 66 of the November 1, 2007 Answer are best understood by the Appellants, the Examiner is likely referring to the opposite curved ends terminating first region (512) in Figure 22 of *Wasshuber* when he identifies "end portions" in paragraph 66 of the November 1, 2007 Answer. Drawings must be evaluated for what they reasonably disclose and suggest to one of ordinary skill in the art. *See* MPEP § 2125. When the reference does not disclose that the drawings are to scale and is silent as to dimensions, arguments based on measurement of the drawing features are of little value. *Id. Wasshuber* fails to indicate that Figure 22 is drawn to scale and fails to disclose specific dimensions for first region (512). However, a description of an article pictured in drawings can be relied on, in combination with the drawings, for what would reasonably be taught to a person having ordinary skill in the art. *Id.* As mentioned above, the written description in *Wasshuber* discloses that the first region extends between two depths (516a, 516b). The written description in *Wasshuber* does <u>not</u> disclose that the two depths (516a, 516b) vary in any way across the width of the first region (512). *Wasshuber* also fails to disclose that any portion of the first region (512) expands by a different amount than any other portion of the first region (512) because of the presence of the implanted oxygen. Hence, the description of Figures 19-22 in *Wasshuber* does not support that "end portions" of the first region (512) have a different thickness than a "central portion" of the first region (512).

In order for a reference to anticipate the invention in a claim, the reference must teach each and every element in the precise arrangement set forth in the claim. *See* MPEP § 2131. *Wasshuber* fails to disclose "said insulating layer containing a thickened region underlying said strained region." For this additional reason, Appellants respectfully request reversal of the Examiner's rejection of claim 1 under 35 U.S.C. § 102(e) for at least this additional reason.

In paragraphs 67 and 68 of the November 1, 2007 Answer, the Examiner disagrees with Appellants' argument that the first region (512) is not an "insulating layer that electrically isolates the island of semiconductor material" and Appellants' argument that the "gaps existing

between the implanted region (512) and the isolation structures (535a, 535b)" would preclude electrical isolation of the channel region (524) from substrate (514) because "small currents" conducted around the "isolating layer does not negate the isolation." Regardless of whether or not small currents can flow through the gaps, this is certainly not the sole reason that there is no electrical isolation of the channel region (524) from the substrate (514). To even reach the conclusion offered in paragraphs 67 and 68 of the November 1, 2007 Answer, the Examiner must draw a threshold conclusion that the first region (512) is an insulating layer, which is itself incorrect for reasons offered above. To reiterate, the first region (512) is not an insulator and, hence, cannot electrically isolate the channel region (524) from the substrate (524). Hence, the Examiner's traversal of the Appellants' argument lacks merit.

B. *Claims 1-4, 6-12, 14, and 15 were improperly rejected under 35 U.S.C. § 102(e) as anticipated by U.S. Pub. No. 2004/0500429 to Yeo et al.*

In paragraphs 81-83 of the November 1, 2007 Answer, the Examiner states in reference to *Yeo* that "an underlying layer is thickened comprises a process limitation that a layer undergoes an expansion to be thickened" and dismisses the limitation as "a product-by-process claim." This rebuttal argument is inappropriate. Appellants are not reciting how the claimed "thickened region" is formed in claim 1. Instead, Appellants are setting forth in claim 1 that a region of the insulating layer (i.e., the "thickened region") has a greater thickness than other regions of the insulating layer. Applicants are not claiming a process (e.g., oxidation) by which a region of the insulating layer is thickened to form the thickened layer.

In any event and as explained in Appellants' September 24, 2007 Appeal Brief, *Yeo* fails to disclose "said insulating layer containing a thickened region underlying said strained region," as set forth in Appellants' claim 1. In particular, *Yeo* fails to disclose that the insulating layer (54) identified by the Examiner has any portion with a different thickness than any other portion. Hence, *Yeo* fails to disclose a thickened region in insulating layer (54).

In order for a reference to anticipate the invention in a claim, the reference must teach each and every element in the precise arrangement set forth in the claim. *See* MPEP § 2131. Because *Yeo* fails to disclose "said insulating layer containing a thickened region underlying said

strained region," *Yeo* fails to anticipate claim 1. For this reason alone, Appellants respectfully request that the Board reverse the Examiner's rejection of claim 1 under 35 U.S.C. § 102(e).

In paragraphs 84-85 of the November 1, 2007 Answer, the Examiner states Appellants' argument that "Yeo does not teach that the inslating *(sic)* layer (54) transfers stress to the strained layer (56)" is incorrect because '[I]f the underlying layer did not stress the overlying layer the overlying layer would not be strained. Without stress from the underlying layer, the overlying layer would relax (i.e., not be strained)." This rebuttal argument is incorrect based upon the intrinsic evidence found in the disclosure of *Yeo*.

Yeo discloses that a strained silicon layer (56) is provided on the insulating layer (54). *Yeo* does not disclose that the insulating layer (54) transfers stress in any manner or by any mechanism to the strained silicon layer (56). The statements by the Examiner in paragraphs 84-85 of the November 1, 2007 Answer are conjecture. In the absence of any express disclosure in *Yeo* that the insulating layer (54) transfers stress to the strained silicon layer (56), an equally plausible (and more likely to be technically correct) explanation is that the strain is graded from 0% strain at the interface between the insulating layer (54) and strained silicon layer (56) to a non-zero strain value in the portion of the strained silicon layer (56) in which carriers are conducted from the source to the drain during device operation.

Based on the disclosure in Paragraph [0031] in *Yeo*, the stain is present in the silicon layer (56) before layer (56) is ever bonded by a "layer transfer technique" to the insulating layer (54) of "silicon oxide" on a "target wafer." Specifically, *Yeo* discloses in paragraph [0031] that the silicon layer (56) is strained when the silicon layer (56) deposited on a "relaxed silicon-germanium layer" that is itself on a "donor wafer," which occurs in the processing sequence before the silicon layer (56) is bonded to the insulating layer (54). *Yeo* discloses in paragraph [0005] that the direct fabrication of strained silicon on insulator substrates is not "straightforward" and is "in an initial stage of research." The method disclosed in Paragraph [0031] solves this problem by circumventing the need to merely transfer strain from an insulating layer to a silicon layer to produce a strained silicon on insulator substrate.

In order for a reference to anticipate the invention in a claim, the reference must teach every aspect of the claimed invention either explicitly or impliedly in the precise arrangement set forth in the claim. *See* MPEP §§ 706.02, 2131. Because *Yeo* fails to disclose "said thickened

region transferring tensile stress to said strained region," Appellants respectfully request that the Board reverse the Examiner's rejection of claim 1 under 35 U.S.C. § 102(e) for at least this additional reason.

Any feature not directly taught by a reference must be inherently present in a reference. The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. To establish inherency, the extrinsic evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient. The Examiner's remarks in paragraphs 84-85 of the November 1, 2007 Answer represent a statement that a certain thing (stress in the silicon layer) may result from a given set of circumstances (strain from the insulating layer) is not sufficient. In fact, the intrinsic evidence in Paragraph [0005] of *Yeo* is that the direct fabrication of strained silicon on insulator substrates is not "straightforward" and is "in an initial stage of research," which is contrary to the Examiner's unsupported conclusions regarding the ability of the insulating layer (54) to strain the silicon layer (56) to introduce the stress. For at least this additional reason, Appellants respectfully request that the Board reverse the Examiner's rejection of claim 1 under 35 U.S.C. § 102(e).

IV. Conclusion

For at least the reasons set forth in the September 24, 2007 Appeal Brief and the reasons set forth herein in Appellants' Reply Brief, Appellants respectfully request that the Board reverse the Examiner's rejections of claims 1-15, and that the application be passed to issue. If there are any questions regarding the foregoing, please contact the undersigned. Moreover, if any other charges or credits are necessary to complete this communication, please apply them to Deposit Account No. 23-3000.

Respectfully submitted,
WOOD, HERRON & EVANS, L.L.P.

Date: December 14, 2007

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